A logo for college computing

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**Assessment Cover Page**

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| *Student Full Name* | Miqueias Sousa dos Santos |
| *Student Number* | 2016287 |
| *Module Title* | *HDip in AI Applications* |
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**Declaration**

By submitting this assessment, I confirm that I have read the CCT policy on academic misconduct and understand the implications of submitting work that is not my own or does not appropriately reference material taken from a third party or other source.

I declare it to be my own work and that all material from third parties has been appropriately referenced.

I further confirm that this work has not previously been submitted for assessment by myself or someone else in CCT College Dublin or any other higher education institution.

Introduction:

The housing market is a complex ecosystem influenced by various socio-economic factors, policies, and trends. Accurately predicting housing prices is crucial for stakeholders like buyers, sellers, and policymakers. Leveraging machine learning algorithms can comprehensively analyze housing data for informed predictions. This project aims to develop and deploy machine learning models for predicting housing prices based on relevant features.

(96 words)

Motivation:

The project is motivated by the housing market's significant role in the economy and society. Housing is essential and a major financial asset. Precise price predictions can empower decision-making for buyers, sellers, real estate agents, and policymakers. By using advanced machine learning techniques, the project aims to enhance prediction accuracy and improve decision-making in the housing market.

(82 words)

Description of the Problem Domain:

The project focuses on understanding the factors influencing housing prices and building models to predict them accurately. Variables such as location, property size, amenities, neighbourhood characteristics, economic indicators, and market trends affect housing prices. Analysing these factors requires sophisticated tools like machine learning. Additionally, factors like population growth, urban development, interest rates, and regulatory changes also play significant roles. By integrating these diverse factors into our models, we aim to provide robust and reliable predictions that can assist stakeholders in making informed decisions in the dynamic housing market landscape.

(141 words)

3**. What is the primary purpose of hyperparameter tuning in machine learning? Could you elaborate on specific hyperparameter tuning techniques (e.g., GridSearchCV) applied to machine learning models to find optimal parameters?**

The primary purpose of **hyperparameter tuning** in machine learning is to find the optimal set of hyperparameters that produces the most accurate predictions for a given model. Hyperparameters are the configuration settings used to train a machine learning model, and they can significantly influence the performance of the model.

There are several techniques for hyperparameter tuning, including:

1. **Grid Search (GridSearchCV)**: This is a traditional way of performing hyperparameter tuning. It works by defining a grid of hyperparameters and then evaluating the model performance for each point on the grid. You can then choose the point that gives the best performance. While this can be very effective, it can also be very time-consuming, especially if you have many hyperparameters.

Below is the GridSearchCV for hyperparameter tuning with a Random Forest Regressor used in the project.

A screenshot of a computer code

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1. **Random Search**: This method randomly selects combinations of hyperparameters to train the model and evaluate performance. The main advantage of this method is that it can be more efficient than grid search if you have a large number of hyperparameters.

**4. Interpret and explain the results obtained, discuss overfitting / underfitting / generalisation, provide a rationale for the chosen models and use visualisations to support your findings. Comments in Python code, conclusions of the project should be specified at the end of the report. Harvard Style must be used for citations and references.**

**Interpretation and Explanation of Results**

Model Performance:

Linear Regression, Ridge, and Lasso: These linear models exhibit decent performance, capturing some of the variability in housing prices. However, they may struggle to capture more complex relationships present in the data, as indicated by their moderate RMSE and R2 scores.

Support Vector Regression (SVR): SVR performs poorly compared to other algorithms, with negative R2 scores suggesting poor generalization to unseen data. This indicates that SVR may be underfitting the data and failing to capture the underlying patterns adequately.

Random Forest Regressor and Gradient Boosting Regressor: These ensemble methods outperform the linear models, demonstrating lower RMSE and higher R2 scores. They excel in capturing complex relationships in the data, leading to improved predictive performance.

Neural Network (MLPRegressor): The Neural Network model shows the worst performance among all algorithms, with high RMSE values and negative R2 scores. This suggests that the model may be overfitting to the training data and failing to generalize well to new instances.

(101 words)

**Overfitting/Underfitting/Generalization:**

Overfitting: Overfitting occurs when a model learns the training data too well, capturing noise and outliers, which leads to poor performance on unseen data. The Neural Network model exhibits signs of overfitting, as indicated by its high training score and poor performance on test data.

Underfitting: Underfitting occurs when a model is too simple to capture the underlying patterns in the data, resulting in poor performance on both training and test data. SVR demonstrates signs of underfitting, as it fails to capture the relationships present in the data, leading to negative R2 scores.

Generalization: Generalization refers to a model's ability to perform well on unseen data. Random Forest Regressor and Gradient Boosting Regressor demonstrate good generalization, as they perform well on both training and test data, indicating that they capture the underlying patterns in the data without overfitting.

(100 words)

**Rationale for Chosen Models:**

Random Forest Regressor and Gradient Boosting Regressor: These ensemble methods were chosen due to their ability to handle complex relationships in the data and their robust performance in predictive tasks. They incorporate multiple decision trees, which reduces overfitting and improves generalization.

(41 words)

Visualizations to Support Findings

**A group of text on a white background

Description automatically generatedfeature** importance plots from ensemble methods like Random Forest Regressor and Gradient Boosting Regressor can highlight the most influential variables in predicting housing prices.

**Conclusion**

In conclusion, ensemble methods like Random Forest Regressor and Gradient Boosting Regressor outperform linear models and neural networks in predicting housing prices. These models demonstrate better generalization and capture complex relationships in the data effectively. However, careful consideration should be given to the potential for overfitting and underfitting when selecting and tuning models for predictive tasks in the housing market domain.

(41 words)